MASK USED FOR LAYER FORMATION AND PROCESS OF MAKING THE MASK

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a mask used when forming a thin layer on a substrate, and a process of fabricating the mask.

2. Description of the Related Art

Vapor deposition, sputtering, CVD and similar processes are used to form thin layers from various kinds of material. The thin layers are shaped to a certain pattern or configuration, depending upon a purpose of use. If the vapor deposition process is performed with a mask having a fine opening pattern, the vapor deposition process can make a thin layer having a desired pattern.

In this vapor deposition process, the mask is firmly attached to a substrate prior to vapor deposition. The material is then vapor-deposited on the substrate. The opening of the mask decides (controls) the area of vapor deposition so that a desired pattern of thin layer is made on the substrate. The mask is prepared by, for example, electroforming.

The process of making the mask by electroforming will be described. First, a plating substrate with photoresist thereon is prepared, and a fine pattern of resist is made on the substrate by photolithography (i.e., the pattern making process). As a result, some areas are covered with the resist and other areas are not on the substrate. Then, a metal is

electro-deposited over the no resist areas on the plating substrate (i.e., the electroforming process). After the electroforming, the deposited metallic layer is removed from the substrate (i.e., the peeling or exfoliating process). The peeled metallic layer becomes the mask which has the opening of the same shape as the resist pattern.

In this manner, the mask has the opening that has a uniform width is prepared. This technique is disclosed in Japanese Patent Kokai No. 10-305670.

The mask is thin so that the mask is easy to bend. Particularly, the mask bends as the mask becomes larger. If the mask bends during the layer forming process, the opening of the mask changes its shape so that the resulting layer does not have a desired pattern.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, there is provided an improved mask assembly having a predetermined opening pattern used to form a thin layer having the same pattern on a substrate. The mask assembly includes a frame having a window. The mask assembly also includes a masking part supported by an edge (periphery) of the window such that the masking part spans (bridges) the window of the frame. The masking part includes a plurality of shielding portions spaced from each other to form the predetermined opening pattern. Each shielding portion has at least one linear element. The shielding portion may have a plurality of parallel linear elements arranged next to each other.

According to another aspect of the present invention, there is provided a method of making a mask assembly. The mask assembly has a predetermined opening pattern used to form a thin layer of the same pattern on a substrate. The method includes providing a masking part that includes a plurality of linear elements arranged next to each other. The method also includes removing predetermined one or more linear elements to form the predetermined opening pattern. Since which linear element(s) should be removed can be determined arbitrarily, it is possible to make the opening having a desired pattern.

Other objects, aspects and advantages of the present invention will become apparent to those skilled in the art to which the present invention pertains from the subsequent detailed description of the invention and the appended claims, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a plan view of a mask assembly used for layer formation according to one embodiment of the present invention;

Figure 2 illustrates a cross sectional view of a modified mask assembly according to the present invention;

Figure 3 illustrates a cross sectional view of another modified mask assembly;

Figure 4 illustrates a cross sectional view of still another modified mask assembly;

Figures 5A to 5C are a set of plan views to illustrate a method of fabricating the mask assembly shown in Figure 1;

Figures 6A and 6B are a set of cross sectional views to illustrate a method of fabricating the mask assembly shown in Figure 3; and

Figures 7A to 7D are a set of cross sectional views to illustrate a method of fabricating the mask assembly shown in Figure 4.

DETAILED DESCRIPTION OF THE INVENTION

A mask assembly according to various embodiments of the present invention will be described with reference to the accompanying drawings.

Referring to Figure 1, a mask assembly 1 used for layer formation includes a rectangular frame 3 having a rectangular window 2. The frame 3 is a rigid plate member made from, for instance, SUS430 (stainless steel). The frame 3 supports a masking portion 4 on the edge of the window 2. The masking portion 4 is firmly attached to the frame 3 by means of adhesive or other connecting element (not shown). The masking portion 4 generally spans the window 2.

The masking portion 4 includes a plurality of shielding (masking) parts 6. Each shielding part 6 includes a plurality of parallel linear elements 5 arranged next to each other. The linear element 5 is a resin wire having a 10-micrometer diameter. It should be noted that three linear elements 5 form a single shielding part 6 in Figure 1, but this is for the sake of easy illustration. In actuality, the shielding part 6 includes more linear elements 5. Ends of the linear elements 5 are located on the edge of the window 2 of the frame 3.

The shielding parts 6 are spaced from each other. The shielding parts 6 and the window 2 in combination define a plurality of rectangular openings 7.

The mask assembly 1 is used for vapor deposition (layer formation). In a vapor deposition machine, the mask assembly 1 is placed such that the frame 3 faces a substrate across the masking portion 4. A vapor deposition material is supplied from the frame side and passes through the openings 7 to reach the substrate. The material then becomes a thin layer having a certain pattern, which is determined by the openings 7, on the substrate. Such vapor deposition process can make, for example, a bus line for organic electroluminescent elements and/or other parts.

It should be noted that the linear elements 5 may be stacked in the thickness direction of the frame 3 or mask assembly 1 (i.e., the direction perpendicular to the drawing sheet of Figure 1) so that the masking part has a multi-layer structure. An example of a masking assembly having a multi-layer masking part is illustrated in Figure 2. In Figure 2, the linear elements 5 (5U, 5L) of each shielding part 6A have a two-layer structure. The lower layer is indicated as the "first layer" and the upper layer is indicated as the "second layer." The linear elements 5L of the lower layer are directly placed on the frame 3, and the linear elements 5U of the upper layer are put on the lower linear elements 5L. In Figure 2, each lower linear element 5L is located below the connecting line of two adjacent upper linear elements 5U. Since each lower

linear element 5L seals a gap between the associated two upper linear elements 5U, the vapor deposition material supplied, as indicated by the unshaded arrow, does not pass the gaps between the upper linear elements 5U. The vapor deposition material flows through the openings 7 only. The multi-layer masking portion 4A includes a plurality of multi-layer shielding parts 6A to define the modified masking assembly 1A.

Referring to Figure 3, another masking assembly 1B is illustrated. The masking assembly 1B includes a plurality of modified shielding parts 6B. Each shielding part 6B includes a coating layer 8 that covers the linear elements 5. The coating layer 8 seals a gap between each two adjacent linear elements 5. Thus, the vapor deposition material (unshaded arrow) do not pass the gaps of the linear elements 5. The resulting masking portion is designated at 4B.

Instead of the coating layer 8, a suitable film may be employed. As shown in Figure 4, a film 9 may be attached over the linear elements 5 of each shielding part 6C. The resulting masking portion is designated at 4C, and the resulting masking assembly is designated at 1C.

Now, a process of making the mask assembly will be described.

Firstly, referring to Figure 5A, the frame 3 having the window 2 is prepared. Then, the linear elements 5 are provided on the frame 3 to completely close the window 2 as indicated at 4' in Figure 5B.

The parallel linear elements 5 are arranged close to each

other and firmly attached to the frame 3 by an adhesive or other suitable connector. Arranging and attaching the linear elements 5 may be performed simultaneously or successively. Alternatively, arranging a certain number of linear elements 5, followed by the attaching process, may be repeated until the linear elements 5 close the entire window 2 of the frame 3.

Tension is applied to the linear elements 5 when the linear elements 5 are attached to the frame 3. Therefore, the linear elements 5 (or the mask portion 4') which span the window 2 do not bend or become loose.

After the mask portion 4' is fixed to the frame 3, at least one linear element 5 is removed to form the opening(s) 7 as shown in Figure 5C. The width of each opening 7 is determined by the number of the removed linear elements 5 and the diameter of each linear element. Accordingly, it is possible to arbitrarily determine the size (width) of each opening 7. It is also possible to arbitrarily determine the location of each opening 7.

If the linear elements 5 are stacked, the processes of Figures 5B and 5C are repeated. For example, when the mask shown in Figure 2 is fabricated, the lower layer of linear elements 5L are laid on the frame 3, some of the lower linear elements 5L are removed, and then the upper layer of linear elements 5U are laid over the lower linear elements 5L, and some of the upper linear elements 5U are removed to form the openings 7.

It should be noted that, as shown in Figure 3, coating layers 8 may be provided over the linear elements 5 to seal gaps

of adjacent linear elements 5, before or after the process of Figure 5C. The coating layers 8 may be formed by vapor-depositing a resin on the linear elements 5. This will be described with reference to Figures 6A and 6B.

When the predetermined linear elements are removed and the openings 7 are formed as shown in Figure 6A, the coating layers 8 are formed over the remaining linear elements 5 as shown in Figure 6B. This is an example when the coating layers 8 are formed after the process of Figure 5C.

Alternatively, if the coating layer formation is performed before the process of Figure 5C (i.e., if the coating layers 8 are formed over all the linear elements 5), the coating layers 8 applied onto the unnecessary linear elements 5 are removed together with the unnecessary linear elements 5 when the unnecessary linear elements 5 are removed.

It should also be noted that, as shown in Figure 4, films 9 may be provided over the linear elements 5 to seal gaps of adjacent linear elements 5. The films 9 may be attached to the linear elements 5 by an adhesive. This will be described with reference to Figures 7A to 7D.

First, the linear elements 5 are arranged side by side as shown in Figure 7A. Then, the film 9 is applied to the linear elements 5 as shown in Figure 7B. The film 9 is, for example, a metallic foil, and is attached to the linear elements 5 by a suitable adhesive.

Subsequently, the linear elements 5, together with the film 9, are firmly secured on the frame 3 as shown in Figure

7C. Then, predetermined linear elements 5 are removed to form the openings 7 as shown in Figure 7D. When the unnecessary linear elements 5 are removed, the associated film is also removed. As a result, the mask 1C is prepared.

It should be noted that the linear element 5 is circle in the cross sectional shape in the foregoing description, but the present invention is not limited in this regard. For instance, the linear element 5 may be polygonal in the cross sectional shape.

All the linear elements 5 may not be made from a single material. For example, if the linear elements 5 are categorized into "unnecessary" or "to be removed" elements and "necessary" or "to remain" elements, the "to be removed" elements may be made from an acid-corrosive material and the "to remain" elements may be made from an acid-resistive material. The "to be removed" elements are those linear elements which are removed in the process of Figure 5C to form the openings 7. The frame 3 may also be made from the acid-resistive material. In this case, the process of Figure 5C to remove the unnecessary linear elements can be performed by immersing all the linear elements together with the frame 3 (Figure 5B) in an acid pool (not shown).

If the linear elements 5 and frame 3 deform upon heating, the linear elements 5 may be fused and fixed to the frame 3 by heating. In this case, no fixing agent such as an adhesive is needed to connect the linear elements 5 onto the frame 3.

The shape and location of the window 2 and the shape of the frame 3 are not limited to those illustrated and described.

For instance, the window 2 may have any suitable polygonal shape.

This application is based on a Japanese patent application No. 2003-15935, and the entire disclosure thereof is incorporated herein by reference.